Continuous Exposure to Ambient Air Pollution and Chronic Diseases: Prevalence, Burden, and Economic Costs

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Abstract

Studies that assess the connection between the prevalence of chronic diseases and continuous exposure to air pollution are scarce in developing countries, mainly due to data limitations. Largely overcoming data limitations, this study aimed to investigate the association between the likelihood of reporting a set of chronic diseases (diabetes, cancer, stroke and myocardial infarction, asthma, and hypertension) and continuous exposure to CO, NO_2, O_3, and PM10. Using the estimated associations, the disease burden and economic costs of continuous exposure to the air pollutants were also approximated. A 2011 HEART survey from Tehran, Iran, was used in the main analyses. A sample of 67,049 individuals who had not changed their place of residence for at least two years before the survey and reported all relevant socioeconomic information was selected. The individuals were assigned with the average monthly air pollutant levels of the nearest of 16 air quality monitors during the two years leading to the survey. Both single- and multi-pollutant analyses were conducted. The country's annual household surveys from 2002–2011 were used to calculate the associated economic losses. The single-pollutant analysis showed that a one-unit increase in monthly CO (ppm), NO_2 (ppb), O_3 (ppb) and PM10 ($\mu g/m^3$) during the two years was associated with 751 (CI: 512–990), 18 (CI: 12–24), 46 (CI: -27–120), and 24 (CI: 13–35) more reported chronic diseases in 100,000, respectively. The disease-specific analyses showed that a unit change in average monthly CO was associated with 329, 321, 232, and 129 more reported cases of diabetes, hypertension, stroke and myocardial infarction, and asthma in 100,000, respectively. The measured associations were greater in samples with older individuals. Also, a unit change in average monthly O_3 was associated with 21 (in 100,000) more reported cases of asthma. The multi-pollutant analyses confirmed the results from single-pollutant analyses. The supplementary analyses showed that a one-unit decrease in monthly CO level could have been associated with about 208 (CI: 147–275) years of life gained or 15.195 (CI: 10.296–20.094) thousand USD in life-time labor market income gained per 100,000 30-plus-year-old Tehranis.

Key Words: ambient air pollution, continuous exposure, chronic disease, burden of disease, economic cost.

1. Introduction

In the past two decades, because of remarkable improvements in the quality of air pollution and health data, the number of studies that examined the relationship between high-cost chronic diseases and air pollution considerably increased. A large body of literature has shown a positive association between the incidence or prevalence of different types of diabetes and increased levels of ambient air pollutants for all age-groups (1−7). In addition, increased levels of air pollutants are shown to be positively associated with the increased risk of lung cancer and lung cancer mortality (8−13), stroke and myocardial infarction (14−19), asthma (20−22), and blood pressure and hypertension (23−25).

One particular aspect of the new wave of research is its focus on the relationship between chronic diseases and long-term or continuous exposure to air pollutants. Despite short-term assessments of exposure that account for air pollutants' levels in the day, week, or month of a medical examination or diagnosis, long-term exposure assessments account for air pollutants' levels in prior months or years. Research that studied continuous exposure often considered the population of more developed counties and examined cancer and diabetes. There is much less research on the association of circulatory and respiratory diseases with continuous exposure to air pollutants, especially on populations of developing countries.

Citizens of Middle Eastern and North African (MENA) megacities, such as Cairo, Istanbul, Karachi, and Tehran, are exposed to extraordinary levels of air pollution, much greater than the levels examined by the literature and the levels recommended by international and national health and environmental agencies (26, 27). As a result, in the MENA region, the percentage of all-cause deaths attributable to air pollution has consistently been greater than that in all other regions (28). As an example, Tehran had 218 unhealthy, very unhealthy, or hazardous days in 2011, according to the air quality index (AQI) reported by the City (29). While the number of such days has decreased in recent years and reached

108 in 2017, for example, the concentration of different air pollutants was still well above the levels recommended by the World Health Organization, WHO (29, 30).

Until recently, lack of suitable data—namely, individual-level health microdata and high-frequency high-resolution air quality data—had made it difficult to empirically examine the relationship between chronic diseases and continuous exposure to the remarkably low levels of air quality in a Middle Eastern megacity. Largely overcoming these problems, we conducted a retrospective study to examine the association of continuous exposure to ambient CO, NO_2, O_3, and PM10—mostly traffic-originated (26, 27)—with the likelihood of reporting diabetes, cancer, stroke and myocardial infarction, hypertension, and asthma among citizens of Tehran. Further, we used the estimated associations in the calculation of the burden of the chronic diseases in terms of the years of life lost and their labor and non-labor market costs.

2. Methods

2.1. Study population

For individual-level health information, we used data from an urban HEART survey, designed by the WHO Center for Health Development and conducted by the Municipality of Tehran in October 2011. Collected according to a stratified multistage cluster sampling method, the HEART survey includes a representative sample of Tehrani households from its all 22 districts. The survey includes 33,915 households and 118,464 individuals. The survey provides detailed information on surveyed individuals' socioeconomic characteristics, access to and utilization of health care, their physical, physiological, mental, and social health, self-assessed quality of life, and chronic diseases such as diabetes, cancer, stroke and myocardial infarction, hypertension, and asthma. Most of the survey's questions pertain to the month or year leading to interview. Questions on the chronic diseases are accompanied by a flag variable indicating if one had the disease during the interview.

Knowing individuals' place of residence is the key piece of information in the approximation of their exposure to ambient air pollutants. The survey reports the 10-digit postal code (the exact address) of most households' place of residence. For 10,122 of them, however, the postal code is either not reported or misreported. Socioeconomic characteristics of those with and without usable postal code were not different. We divided those with usable postal code (108,342 individuals) into 1,872 city areas according to the first five digits of the postal code. Then, we used the city's map, provided by Iran's National Cartographic Center, and the ArcGIS software and extracted geographical coordinates (latitude and longitude) of the middle point of the 1,872 areas. Next, using the coordinates of the five-digit postal codes and coordinates of air quality monitors, we determined the closest monitor to each household.

Another important piece of information provided by the data is the household's length of stay in its current place of residence; otherwise, the assignment of exposure to ambient air pollutants would suffer from serious measurement error originated from households' moves from one location to another. Since we accounted for exposure to air pollutants in the two years leading to the HEART interview dates, we limited the sample of households to those resided in their place of residence for at least two years. This constraint led to the dropping of 15,983 individuals.

Among the remaining 92,359 individuals, a key piece of information, age, is not reported for 17,591 individuals. In the rest, 74,768 individuals, we kept those who reported their chronic diseases' status and socioeconomic background information, such as gender, education, economic activity, and health insurance. Ultimately, our final sample included 67,049 individuals.

2.2. Ambient air pollution data

We used hourly ambient air pollutants' data, collected by air quality monitors separately installed by Municipality of Tehran (MoT, henceforth) and the country's Department of Environment (DoE, henceforth) across the city's metropolitan area. The number and coverage of both organizations' monitors have increased over time. The MoT had only one monitor in a northeast district of the city in 2000, installed three other monitors in two northwest districts and one in a southern district in 2006, and expanded them to sixteen in 2011 and to twenty-two in 2018, covering almost all districts of the city. The DoE had six air quality monitors in 2000 but expended them to eighteen in 2018.

In October 2011, when the HEART was underway, twenty-two monitors (sixteen from the MoT and six from the DoE) were collecting ambient air pollution information. The monitors did not collect information on the same set of pollutants. Also, sometimes they stopped working or reported erroneous pollutant concentration values, e.g., negative or impossibly large values. We used a monitor's recorded data if they were available and acceptable for at least 75% of hours in a day and days in a month. Considering carbon monoxide, for example, 16, 13, 7, 5, and 3 of the 22 monitors continuously reported acceptable concentration levels for at least 1, 2, 3, 4, and 5 years, respectively, before October 2011.

2.3. Length of exposure

The decision on the choice of the length of exposure to air pollutants considered all the limitations above, especially the timing of installation of air quality monitors. Selecting shorter terms, one year, for example, before the HEART survey leads to using data from more monitors hence increasing the cross-sectional variation in air pollutants' levels. Nonetheless, one year's air quality can be affected by specific events of that year. On the other hand, if the selected period is three years or longer, the number of monitors significantly decreases, so does the cross-sectional variation in the air pollutants' levels. All in all, we focused on the two years before the HEART survey.

In the two years leading to the HEART survey (i.e., October 2009 to September 2011), 16 different monitors reported continuous and acceptable data on ozone (O_3), 15 on nitrogen dioxide (NO_2), 14 on coarse particulate matter (PM10), and 13 on carbon monoxide (CO). The monitors are scattered virtually evenly throughout the city, covering populations living in all districts (Figure 1). For other air pollutants—such as sulfur dioxide (SO_2), black carbon (BC), fine particulate matter (PM2.5)—there were very few monitors with continuous and acceptable data to be considered in our analysis.

2.4. Measures of exposure

On any given day during the period, we measured an individual's exposure to a specific air pollutant by its concentration level at the nearest air quality monitor to the individual's place of residence. We calculated average monthly exposure levels from daily and hourly exposure values. Then, we found the average, median, and maximum of the 24 monthly averages. We focused on the average of the monthly averages because it uses all air pollution data; the median and maximum of the monthly averages represent data of only 30 or 31 days. Nonetheless, when median and maximum exposure measures were used, the results were consistent with those from the average exposure measures.

During the two years, concentration levels of the ambient air pollutants in Tehran were remarkably greater than what is recommended by the WHO and other major environmental watchdogs. For example, the interviewees were exposed to an average monthly CO level of 3.6 ppm (parts per million), while the US Environmental Protection Agency (EPA) does not allow greater than 9 ppm CO level in only "8 hours" (31). Also, they were exposed to an average monthly NO_2 level of 53.9 ppb (parts per billion), while the EPA enforces and the WHO recommends average "annual" levels below 53 and 21 ppb, respectively (30, 31). In terms of O_3, the average monthly level in Tehran was 22.7 ppb, while the EPA enforces and the WHO recommends average "8-hourly" levels below 70 and 50 ppb, respectively (30, 31). For PM10, the average monthly level was 102 $\mu g/m^3$, while the EPA enforces and the WHO recommends average daily levels below 150 and 50 $\mu g/m^3$ (30, 31).

2.5. Statistical analysis

The concentration of the air pollutants noticeably varied across monitors. Specifically, the average monthly CO, NO_2, O_3, and PM10 levels varied in the ranges of 1.4–5.2 ppm, 22.2–91.4 ppb, 12.1–32.7 ppb, and 58.1–137.8 $\mu g/m^3$, respectively. Across groups of 30-plus-year-old individuals assigned to the thirteen monitors used in the CO analysis, for example, the average rate of prevalence of diabetes, cancer, stroke and myocardial infarction, hypertension, and asthma varied in the ranges of 2.3%–8.1%, 0.0%–0.8%, 1.3%–5.3%, 5.6%–11.6%, and 0.8%–2.0%, respectively. For 60-plus-year-old individuals, the corresponding variation ranges were 5.4%–21.6%, 0.1%–1.5%, 3.5%–9.1%, 13.6%–25.6%, and 0.0%–3.1%, respectively. The average rate of prevalence of the five chronic diseases in the 30-plus and 60-plus years olds varied in the range o 9.6%–19.0% and 21.4%–40.5%, respectively.

Such large variations in exposure to the air pollutants and the prevalence of the chronic diseases across the air quality monitors allow for conducting statistical analyses to investigate if there were any relationships between the chronic diseases and the air pollutants. We set up controlled single-pollutant and multi-pollutant regression analyses in which the left-hand-side variable was an indicator of individual's affliction by one of the chronic diseases, and the right-hand-side variables were the exposure measure(s), three basic personal characteristics (age, body mass index, and gender), a set of key individual-level socioeconomic attributes (type of economic activity and education level), a set of household-level background factors (health insurance status, ownership of a car, access to computer at home, and city district), and interactions of the exposure measure(s) with district-specific socioeconomic factors.

Age and BMI are two known risk factors for the chronic diseases of interest (28, 32, 33). Also, male individuals may generally be at a higher risk of affliction (34−36). Moreover, the literature shows that employment and higher education are correlated with a lower probability of chronic diseases (37, 38). We categorized individual's economic activity to seven types (i.e., employed, job seeker, unemployed with income, retired, homemaker, student, other) and education to four levels (i.e., illiterate or some primary school, some secondary school, high school diploma, and some college).

We examined controlling for a host of household-level background factors such as size, total expenditures, savings, amenities, access to utilities, features of the residence, district of residence, and access to health care. As most of the household level factors are highly correlated, we included a set of most influential ones—namely, the city district, access to health care, having a computer at home, and ownership of a car—in the analysis. Summary statistics of the variables showed variations in the individual- and household-level socioeconomic factors across the city's 22 districts (Tables 1-a and 1-b, respectively, for 30-plus and 60-plus-year-old individuals), justifying controlling for the variables.

Suspecting that a potential relationship between the likelihood of chronic diseases and exposure to air pollution may be nonlinear, we examined the inclusion of interactions of the measures of air pollution with district-specific socioeconomic factors. Specifically, we included the interactions of the exposure measures with an index of district-specific level of college education (set equal to 1 if the rate of college education among the 30-plus-year-olds at the district was greater than 20%; 0 otherwise).

We estimated the statistical models using the ordinary least squares method. Hence, we could directly interpret the estimated coefficient(s) of the exposure measure(s) as the association between the chronic disease of interest and the average monthly exposure to the ambient air pollutant of interest, in percentage. Since the left-hand-side variable in the statistical models is binary, it is common to use the logit regression method. We reported the estimates of linear probability models (LPM) because 1) their results, apart from being straightforward to interpret, could be easily used in the calculation of burden of diseases and economic costs; 2) the estimations of the marginal associations at means using logit regressions produced very similar results to what we found using LPMs; 3) more than 98% of our LPMs' predicted values that fell in the 0–1 range. To account for similarities of individuals within each city district, we clustered standard errors at the district level (39). We estimated our LPMs in Stata 15.0 (STATA, Inc, College Station, Texas, USA).

In addition, we discussed the potential relationship between the estimated associations and life expectancy and income. Specifically, we approximated years of life lost (YLLs) due to the chronic diseases due to a change in the air pollutants. YLLs are metrics of premature death in a population. For example, the YLLs attributable to diabetes are equal to the number of deaths caused by diabetes in the population of interest times the standard life expectancy (taken as Japanese men's and women's life expectancy) at the age of death (40). Then, using the approximated changes in YLLs, we assessed the potential income gains from a persistent decrease in air pollution.

2.6. Limitations of the statistical analysis

Exposure to air pollution varies by household location, which itself is influenced by household wealth, social network, and preferences. The underlying factors can simultaneously influence the prevalence of chronic diseases. If they are unobserved or their influence mechanism is unaccounted, the estimated associations suffer from endogeneity bias.

By focusing on those who resided in one place in the two years before the survey, we effectively excluded all moves in response to a change in air quality during the period. As the possibility of such moves is often determined by households' financial means and social networks, the exclusion partly limits the extent of the endogeneity bias—in addition to improving the accuracy of the assignment of exposure to individuals. Nevertheless, the choice of location before the two years can be endogenous. To account for the latter, information on households' wealth and resources right before the two-year period is needed. Such information is not available as the HEART survey is not longitudinal. Instead, information on households' "current" wealth such as its total expenditures and savings, features of the place of residence (e.g., ownership, number of rooms, and area), and ownership of major durables (e.g., car, home appliances, computer, and cellphone) is available. The magnitude of the bias depends on the correlation between these indicators of wealth in October 2011 and September 2009. The correlation is expected to be strong. However, if an unobserved factor is undermeasured by the indicators and is negatively correlated with both the likelihood of chronic diseases and exposure to air pollution, then the associations were underestimated. An example of such factors is the ownership of an estate in the country to escape from the city's polluted air.

The estimated associations may also suffer from two types of measurement errors. One is the potential underreporting of chronic diseases: in comparison to higher-income individuals, a larger number of lower-income individuals might not have known about their chronic diseases because of their limited access to health care. We expect controlling for health insurance status, district, education, and wealth indicators accounts for such underreporting. If any variation in the potential underreporting remains unexplained by these variables, then the associations are underestimated.

Another potential source of measurement error is the imprecise assignment of air pollution to individuals because of 1) the assignment of a monitor's measurements to all households under a specific radius around it, 2) the assumption that individuals commutes took place mostly around the monitor, and 3) ignoring variation on indoor exposure to air pollutants. To assess the first error, we included household distance from the nearest monitor in the statistical model, but it did not change the results. The second error is stronger for those who work farther outside the coverage of their nearby air quality monitor. We expect controlling for economic activity type partly addresses this concern, but we cannot conjecture on the direction of the effect of any uncontrolled variation in such misassignments. To assess the third error, we compared the rates of consumption of tobacco products by monitor coverage and found no statistically significant difference. Further examination of the error requires information on household fuel type, not reported in the survey.

3. Results

We ran age-specific linear probability models for each of the chronic diseases (Table 2 provides the total number of observations and variation in reporting the chronic diseases for each of the models). The estimated associations between each pair of chronic disease and air pollutants from the single-pollutant models are presented in Table (3), where each entry is a result of a separate model. We provided a direct, generic presentation of the results in which we assume a one-unit change in the air pollutants' concentration—namely, one ppm, ppb, ppb, and $\mu g/m^3$ change in CO, NO_2, O_3, and PM10, respectively. Hence, the results are easily modifiable to any given unit or any number of standard deviations change in concentrations simply by multiplying the presented results by the multiplier of interest (City- and district-level standard deviations in air pollutants' concentrations are presented in Table 1). We did not change the units of the air pollutants' measurement to the international system of units (SI), but the generic presentation of the results allows for easily reproducing them in SI ($\mu g/m^3$) by multiplying the measured associations for a one ppm increase in CO, one ppb increase in NO_2, and one ppb increase in O_3 by 1.1, 1.9, and 2.0, respectively.

A one ppm (cross-sectional) increase in the average monthly CO (i.e., an about 25% increase over its overall city-level average) was associated with reporting 751 more cases of chronic diseases, in 100,000, regardless of age. Our age-specific estimations showed that the association noticeably increased by age from 1,240 to 1,870, 2,360, and 2,740 (in 100,000) for 30-plus, 40-plus, 50-plus, and 60-plus-year-old individuals, respectively, although the difference between the associations at the highest two age ranges was not statistically significant due to decrease in statistical power (Table 3).

The main contributors to the large association between exposure to CO and the prevalence of chronic diseases were diabetes, hypertension, and stroke and myocardial infarction. Regardless of age, a one ppm increase in monthly CO was associated with 329, 321, 232 in 100,000 more reported cases of diabetes, hypertension, and stroke and myocardial infarction, respectively. For diabetes, the size of the association for 30-plus-, 40-plus-, 50-plus-, and 60-plus-year-old individuals was 528, 854, 1,380, and 1,350 (in 100,000), respectively, where the difference between the latter two was statistically insignificant. For hypertension, the sizes of the corresponding associations were 574, 829, 868, and 1,630 in 100,000, although the latter association was statistically insignificant. For stroke and myocardial infarction, the associations amounted to 407, 606, 833, and 901 in 100,000, respectively, although the latter association was statistically insignificant. We estimated an association between exposure to CO and asthma (185 in 100,000 increase in prevalence for a one ppm increase in monthly concentration) for 30-plus years olds but none between CO and cancer (Table 3).

For NO_2, one ppb increase was associated with 18 to 33 in 100,000 more cases of chronic diseases reported, depending on age. A 6.75 ppb increase in NO_2 (equivalent to 25% increase over its city-level average) was associated with reporting 121 to 223 in 100,000 more cases of chronic diseases, depending on age. However, no statistically significant positive association between exposure to NO_2 and a specific chronic disease was measured (Table 3).

Like NO_2, a statistically significant association between exposure to PM10 and the general likelihood of reporting chronic diseases but no statistically significant association for any specific disease was measured. The size of the overall, regardless of age association was 24 in 100,000 for a one $\mu g/m^3$ increase in PM10 or 635 in 100,000 for a 20% increase in PM10 over its city-level average (Table 3).

Statistically significant associations between exposure to O_3 and asthma were measured. Specifically, a one ppb increase in monthly exposure to O_3 (about 4.4% over its city-level monthly average) was associated with an average of 21 in 100,000 increase in the prevalence of asthma. Alternatively, a 25% increase over the city level average of O_3 concentration was associated with about 119 in 100,000 more reported cases of asthma. The magnitude of the association increased by age such that a 25% increase in O_3 over its city-level average was associated with an about 267, 357, and 610 in 100,000 more cases of reported asthma for the 40-plus-, 50-plus-, and 60-plus-year-olds, where the latter was statistically insignificant (Table 3).

We tested if the findings from single-pollutant analyses would hold under multi-pollutant analyses, where measures of exposure to all air pollutants were inserted at the right-hand-side of the statistical models. Table (4) reports the correlations between the concentration of the pollutants for air quality monitors whose CO levels were used in this study. In most stations for which both NO_2 and CO levels were reported, the correlation between the two was large, sometimes well above 50%. Also, in most stations, the correlation between NO_2 and O_3 levels was rather large, in a 30%–55% range. Hence, suspecting that the inclusion of NO_2 in the multi-pollutant regressions would lead to a multicollinearity problem, we excluded it. In effect, signs of multicollinearity (e.g., changes in the sign of some exposure measures and the size of some standard deviations) appeared with the inclusion of NO_2.

Table (5) presents the results of estimating the multi-pollutant models. In effect, the results from single-pollutant analyses were largely confirmed by the multi-pollutant analyses. In both single- and multipollutant analyses, an increase in average two-yearly exposure to CO had the strongest and most consistent association with an increase in the likelihood of reporting chronic diseases—especially diabetes, hypertension, and stroke and myocardial infarction—in comparison to O_3 and PM10. The magnitudes of the statistically significant associations from multi-pollutant analyses were very close, although a bit smaller as expected, than those from the single-pollutant analyses. Also, the association of exposure to O_3 and asthma was confirmed in multi-pollutant analyses. Nonetheless, the statistically significant associations between exposure to PM10 and the general likelihood of reporting a chronic disease at ages 30- and 40-plus year disappeared in the multi-pollutant analyses.

4. Discussion

We related the measured associations to life expectancy (measured by YLLs) and income. We based the calculations on 2011 because 1) the estimated associations are for 2011 2) there is accurate population information for 2011 as it was a census year.

4.1. Potential burden of disease gains of persistent improvement in air quality

The latest results from the Global Burden of Disease project (GBD)—annually conducted by Institute for Health Metrics and Evaluation (IHME)—provides estimations of the burden of 282 causes and the attributable burden of 84 risk factors from 1990 to 2017 (28, 32). We used the GBD's age-specific estimations of YLLs attributable to the causes of interest (diabetes, stroke and myocardial infarction, and asthma) and the risk factor of interest (hypertension), for which we found statistically significant associations with one or more air pollutants. Since we did not find a statistically significant association between the likelihood of reporting cancer and exposure to any of the air pollutants, we excluded cancer from this discussion. Also, we assumed YLLs provided for Iranians are the same as those for Tehranis.

The GBD's county- and age-specific results are provided for five-year age-groups (e.g., 30–34, 35–39, etc.); whereas, we estimated the associations for 30-plus-, 40-plus-, 50-plus-, and 60-plus-year-old individuals. To find YLLs that correspond to the age-groups of this study, we weighted the GBD's estimated YLLs with the sample shares of the matching age-groups. In effect, we calculated:

$$YLLs_{l+}^{k} = \sum_{j=l-(l+4)}^{90-94} \omega_j . YLLs_j^k$$

where l=30, 40, 50, or 60, $YLLs_j^k$ is the GBD's estimation of YLLs attributable to the chronic condition k for age-group j, and ω_j is the share of individuals in the age-group j in the sample. For example, the YLLs attributable to diabetes among the 60-plus-year-old Iranians are calculated from:

$$YLLs_{60+}^{diabetes} = \sum_{j=60-64}^{90-94} \omega_j . YLLs_j^{diabetes}$$

$$= \omega_{60-64} . YLLs_{60-64}^{diabetes} + \omega_{65-69} . YLLs_{65-69}^{diabetes} + \cdots + \omega_{90-94} . YLLs_{90-94}^{diabetes}$$

where the variables $YLLs_{60-64}^{diabetes}$, $YLLs_{65-69}^{diabetes}$, …, and $YLLs_{90-94}^{diabetes}$ are the years of life lost due to premature death caused by diabetes among the 60−64-, 65−69-, …, and 90−94-year-old Iranians, calculated and reported by the GBD (28, 32). The variables ω_{60-64}, ω_{65-69}, …, and ω_{90-94} are the shares of 60−64-, 65−69-, …, and 90−94-year-old individuals in the analysis sample. Inserting the required numbers in the formula, average YLLs were equal to 2,508, 5,259, 541, and 14,306 in 100,000 60-plus-year-olds, respectively, for diabetes, stroke and myocardial infarction, asthma, and hypertension. Table (6), panel (B), provides the results of calculating the YLLs for all age-groups.

Table (6), panel (A), represents the results of the multi-pollutant analyses, namely, the associations between a one ppm decrease in the monthly CO level during two years and decrease in the number of reported cases of diabetes, stroke and myocardial infarction, asthma, and hypertension in 100,000. We assumed that the associations also represent the associations between CO level and burden of the chronic conditions. For example, we assumed that a one ppm decrease in monthly CO level is associated with a 1,370 in 100,000 decreases in the rate of YLLs attributable to diabetes among 60-plus-year-old Tehranis because we found the same decrease in CO was associated with 1,370 in 100,000 decreases in the number of diabetes cases in the age-group.

Given that the prevailing rate of YLLs among the 60-plus-year-old Tehranis was 2,508 per 100,000 (Table 6, panel B), a one ppm decrease in monthly CO level was associated with a (1,370 / 100,000) × 2,508 = 34.4 in 100,000 decrease in the number of years lost due to diabetes in the age-group. The results of all such calculations, per 100,000, are presented in Table (6), panel (C), for all age-groups and chronic diseases, for the same decrease in CO.

Using the total number of 30-plus, 40-plus, 50-plus, and 60-plus-year-old Tehranis from Census 2011 city-level data, we transformed the decreases in the rates of YLLs to total years gained (Table 6, panel D). For example, for 30-plus-year-old Tehranis, the total years of life that could have been gained by a one ppm decrease in average monthly CO level during the two years was approximated as 208, 339, 15, and 1,119—due to fewer cases of diabetes, stroke and myocardial infarction, asthma, and hypertension, respectively.

4.2. Potential income gains of persistent improvement in air quality

Having the estimated years of life that could have been gained due to a hypothetical one ppm decrease in average monthly CO level in Tehran, we calculated labor and non-labor market incomes that could have been gained due to the decrease. For this purpose, we used Iranian Household Expenditure and Income Surveys (HEIS) conducted by the Statistical Center of Iran. The HEIS is an annual cross-sectional survey that collects detailed information on Iranian households' expenditures on about 1,100 items and their dwelling's characteristics, access to utilities, and ownership of major household items such as car, TV, refrigerator, air conditioner, and computer. It also provides detailed information on household members' socioeconomic characteristics (e.g., gender, age, and education) and their income from three sources, namely 1) self-employment jobs, 2) wage and salaried jobs, and 3) non-labor, miscellaneous sources such as rent, interest, social security, and aids.

We selected Tehranis surveyed by the HEIS and processed their income data. While the HEIS samples are large and include about 38,000 households and about 138,000 individuals—on average—each year, the number of Tehranis is not large enough for a credible income analysis. For example, in HEIS 2011, 3,684 Tehranis were surveyed; among them, only 1,994 were 30 years or older. To increase the sample size, we processed and harmonized data from ten HEIS surveys during the ten year period that led to 2011. Subsequently, our sample size of 30-year plus individuals increased to 19,361. Pooling data from a decade also has the advantage of averaging incomes over economic up and downs hence decreasing the sensitivity of the analyses to particular events. We used sample weights in all labor market calculations, described below.

The chance of having a job, hence labor income, during the 2002–2011 period for a 30-plus-year-old Tehrani was 41.7%. There was a wide gender gap in the chance of employment such that it was 72.8% and 10.2% for males and females, respectively. One the other hand, 24.9% of 30-plus-year-old Tehranis were unemployed but had income, that is, they had one or more non-labor income sources such as rent, interest, and social security. There was a smaller gender gap in terms of having non-labor income: 32.4% versus 17.3% for 30-plus-year-old males and females, respectively. The chance of having labor income decreased, but that of having non-labor income increased as we restricted the sample to older individuals, but the gender gaps were persistent (Table 7).

If a 30-plus-year-old Tehrani held a job during 2002–2011, then it made an annual labor market income of 9,387 thousand Iranian tomans (TIT) or an equivalent of 7,823 US dollars (USD), both assessed at 2011 prices. If the person had non-labor income, then it averaged at the annual value of 5,984 TIT or 4,987 USD. Only about 5% of 30-plus-year-olds had both labor and non-labor income. In general, a 30-plus-year-old income earner made 8,834 TIT or 7,362 USD a year. Amounts of labor and non-labor incomes were greater in subsamples with older individuals, but a large gender gap in terms of the amount of both types of incomes persisted in all subsamples (Table 8).

Using the chances of engaging in different types of activity (reported in Tables 7) and income levels for those who reported an income (reported in Table 8), expected income levels for 30-plus-, 40-plus-, 50-plus-, and 60-plus-year-old Tehranis were calculated. For a 30-plus-year-old Tehrani, for example, the expected annual labor, non-labor, and total income levels, respectively, were 3,933, 1,483, and 5,416 TIT—or 3,277, 1,236, and 4,513 USDs; for a 60-plus-year-old Tehrani, on the other hand, the expected annual labor, non-labor, and total income levels, respectively, were 1,525, 3,721, and 5,245 TIT—or 1,271, 3,101, and 4,371 USD (Table 9).

The potential income gains from a one ppm decrease in average monthly CO level were approximated from the results in Table (9) and Table 6, panel D. The estimated gains per 100,000 Tehranis, assessed at 2011 prices, are presented in Tables (10–1) to (10–4) where it was assumed that the labor market participation rates and wages in the years after 2011 would remain like those in 2002–2011 period. For example, the lifetime income gain for every 100,000 30-plus-year-old Tehranis from the estimated increase in life expectancy due to a reduction in prevalence of diabetes, strokes, asthma, and hypertension (in turn, due to a one ppm decrease in average monthly CO) amounted to 25.110, 40.962, 1.829, and 135.313 million Iranian tomans (MIT), respectively—or 20.925, 34.135, 1.524, and 112.761 thousand USD. For 40-plus-year-old Tehranis, the corresponding projected lifetime income gains were 57.597, 89.830, 2.267, and 307.122 MIT in 100,000, respectively—or 47.998, 74.758, 1.889, and 255.935 thousand USD in 100,000. These are significant amounts, even without considering potential improvements in quality of life. For comparison, the price of a new, popular brand of car (*Pride*) in 2011 was 7.8 MIT in Iran.

5. Conclusions

The results of this study showed that, in comparison to other ambient air pollutants, exposure to CO is most consistently and significantly associated with the likelihood of reporting diabetes, stroke and myocardial infarction, asthma, and hypertension. The data of this analysis, however, did not provide sufficient statistical power to assess potential associations between air pollution and the likelihood of reporting cancer. Basing the burden of diseases and economic analyses on the CO results, we found that large public health and economic gains can be achieved with a continuous decrease in air pollution. One potential policy to achieve such gains is adjusting the country's fuel prices, which have historically been among the lowest in the world. For example, adjusting the gas price can reduce the concentration of CO, as vehicles are a major source of CO emission. Such an adjustment once took place in 2017 and resulted in an about 18% decrease in the average annual concentration of CO, which had remained unchanged from 2011, in Tehran (29).

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Figure 1: Monitors' and households' locations on Tehran's map with city districts

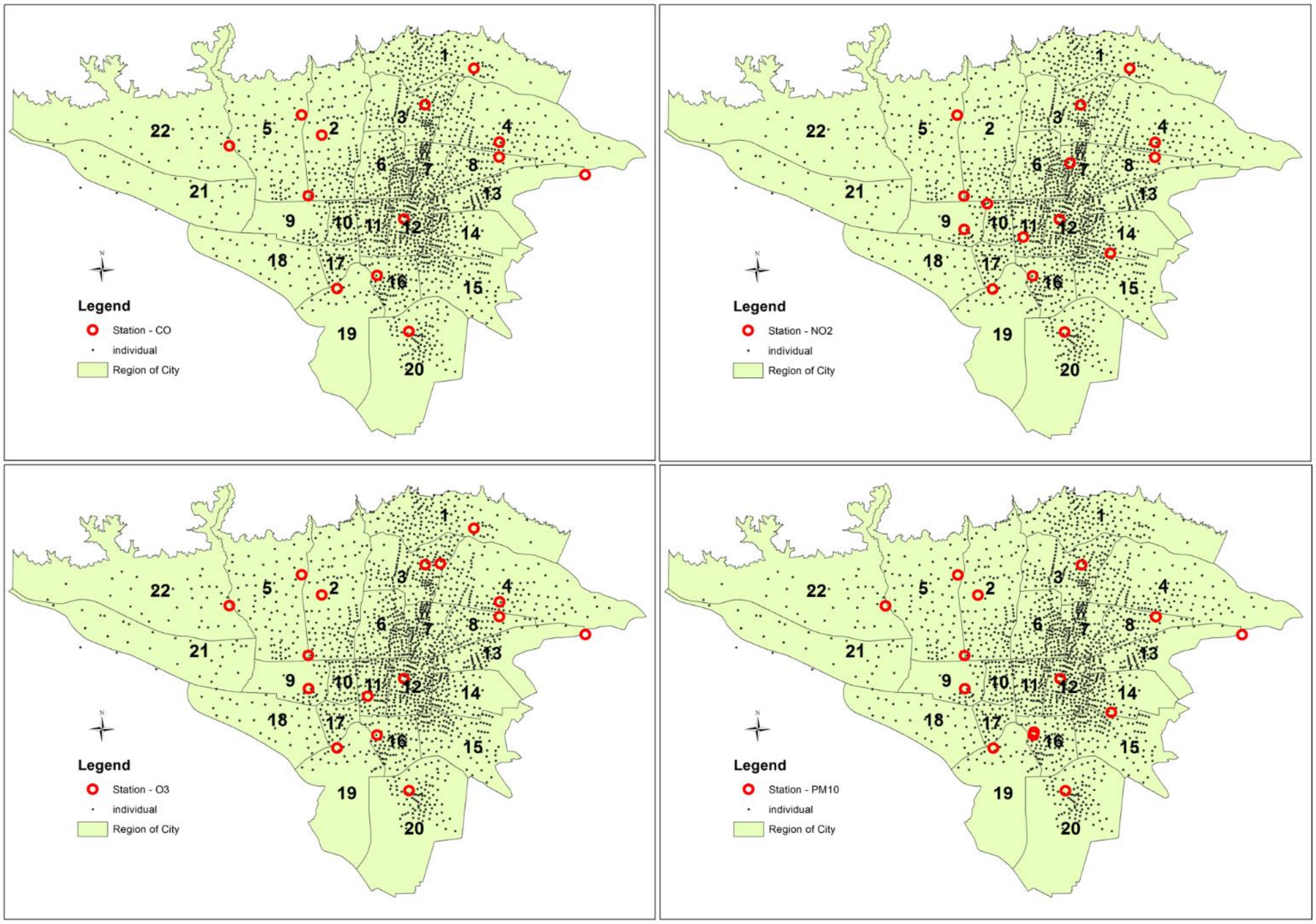

Table 1-a: Number of observations, average monthly air pollution levels, the prevalence of chronic diseases, and individual and household characteristics by city district in the analyses that include 30 years or older individuals (standard deviations in parentheses)

City District	Num. of Obs. (%)	CO (ppm)	NO2 (ppb)	O3 (ppb)	PM10 (µg/m3)	If Any Chronic (%)	If Diabetes (%)	If Cancer (%)	If Stroke (%)	If Hyper-tenssion (%)	If Asthma (%)	Age (year)	Female (%)	BMI (m/kg2)	If Employed (%)	If Un-employed (%)	If Retired (%)	If Home maker (%)	If Student (%)	If health Insurance (%)	If Illiterate (%)	If Some School (%)	If Some High School (%)	If Some College (%)	If Car (%)	If Computer (%)
1	3.6	3.1	50.5	29.1	106.8	13.1	4.9	0.3	1.7	6.8	1.0	50.3	51.9	25.7	37.0	4.3	19.8	35.1	2.3	31.9	2.4	12.7	40.4	44.4	80.4	79.9
		(0.1)	(5.4)	(3.0)	(5.2)							(13.3)		(4.0)												
2	5.6	3.5	79.1	24.9	98.6	19.4	4.2	0.8	2.9	12.3	2.1	51.4	51.6	26.2	32.3	5.6	24.3	33.8	2.3	62.6	2.4	14.5	39.5	43.7	81.2	78.6
		(1.2)	(35.9)	(2.0)	(36.6)							(13.4)		(4.5)												
3	3.2	3.1	44.1	29.7	107.1	16.4	3.2	0.6	3.2	10.2	1.4	52.3	51.3	25.5	35.9	4.4	21.6	34.4	1.9	26.0	1.9	10.8	38.2	49.2	81.1	79.5
		(0.1)	(3.9)	(5.3)	(5.2)							(14.0)		(4.0)												
4	4.8	2.6	74.1	18.1	90.2	16.9	5.9	0.3	3.5	9.2	1.1	49.0	50.8	26.1	34.5	5.3	18.6	38.6	1.2	45.9	6.5	24.2	44.7	24.6	73.7	66.2
		(0.5)	(24.3)	(7.5)	(13.7)							(13.0)		(4.3)												
5	4.8	3.6	58.0	25.1	90.4	16.8	4.4	0.5	3.4	10.2	1.7	49.5	50.1	26.3	33.1	5.3	20.7	37.5	1.4	53.5	3.8	17.5	44.8	33.8	79.2	76.8
		(0.8)	(13.7)	(1.9)	(33.7)							(12.9)		(4.2)												
6	6.2	3.4	49.3	27.1	92.5	18.0	5.9	0.9	2.2	10.9	1.4	53.5	52.0	25.5	33.6	5.6	24.1	32.5	1.8	47.8	3.0	12.1	39.8	45.1	71.9	75.2
		(0.6)	(30.8)	(4.9)	(13.6)							(14.3)		(3.8)												
7	3.8	3.4	38.7	26.2	92.8	16.8	6.0	0.7	3.4	8.7	1.7	49.8	51.2	26.1	41.4	4.3	17.0	35.6	0.8	53.7	5.1	18.0	46.2	30.6	66.1	67.0
		(0.5)	(11.3)	(3.1)	(6.7)							(13.7)		(4.4)												
8	5.1	2.6	34.7	22.5	90.4	19.1	6.6	0.6	3.1	12.1	1.6	50.9	51.7	26.1	36.8	4.3	19.0	37.8	0.9	40.8	5.4	25.1	47.4	22.0	66.9	65.6
		(0.1)	(8.9)	(1.8)	(2.7)							(13.9)		(4.3)												
9	4.5	5.2	71.3	20.0	133.2	16.9	5.0	0.3	2.9	10.8	1.3	48.4	50.3	26.3	35.7	4.8	16.5	40.6	1.2	51.5	10.7	29.4	45.5	14.4	57.0	55.7
		(0.2)	(41.3)	(1.4)	(9.2)							(13.4)		(4.2)												
10	4.5	4.6	86.1	14.6	130.4	9.0	2.4	0.3	1.6	5.2	0.7	48.0	50.8	26.1	36.9	5.6	14.9	40.1	1.4	51.3	7.8	28.1	47.2	16.9	52.4	60.2
		(1.0)	(41.7)	(4.8)	(17.1)							(13.2)		(4.2)												
11	4.5	3.5	61.5	13.9	88.3	12.4	3.5	0.7	1.9	7.8	1.2	47.8	49.6	26.5	41.0	4.5	14.6	36.6	1.1	59.0	6.2	23.0	48.5	22.3	56.9	63.9
		(0.5)	(21.3)	(6.2)	(8.4)							(13.4)		(4.4)												
12	4.6	3.7	72.0	25.6	93.4	13.7	2.9	0.4	2.4	8.6	1.5	48.8	49.7	26.5	37.8	6.4	10.4	41.6	1.2	45.2	11.8	29.4	43.7	15.1	50.4	56.2
		(0.3)	(11.3)	(4.1)	(13.6)							(12.8)		(4.5)												
13	4.2	2.9	44.7	24.1	98.5	8.8	2.9	0.2	1.1	5.3	0.7	49.3	50.2	26.2	38.6	6.6	14.7	36.0	2.2	49.1	4.8	23.7	48.8	22.7	67.0	66.5
		(0.6)	(17.2)	(2.1)	(17.5)							(13.1)		(4.3)												
14	5.5	3.6	51.0	26.4	131.1	17.0	5.6	0.4	2.5	10.0	1.6	49.5	50.0	26.7	35.9	4.4	15.8	41.3	1.1	45.1	9.7	32.5	43.2	14.6	58.4	57.2
		(0.4)	(7.9)	(1.6)	(12.4)							(13.5)		(4.4)												
15	4.4	4.2	46.4	22.1	127.1	13.7	2.8	0.6	2.0	8.4	1.7	47.0	48.5	26.7	40.1	5.3	9.8	42.0	0.8	42.9	13.6	40.0	37.5	9.0	57.7	47.0
		(0.7)	(8.2)	(3.7)	(22.9)							(12.3)		(4.5)												
16	3.4	2.8	48.5	16.9	86.9	14.0	3.3	0.3	1.7	9.9	1.3	47.6	50.7	26.7	37.2	5.6	12.3	41.2	1.5	55.2	15.2	35.1	39.0	10.7	49.4	45.4
		(0.8)	(10.9)	(2.1)	(14.1)							(13.5)		(4.4)												
17	4.1	3.7	45.4	18.2	107.8	6.6	2.2	0.2	0.9	3.8	0.4	47.0	50.6	26.4	36.1	5.1	14.0	41.7	1.7	36.1	18.3	38.4	33.2	10.1	46.0	47.8
		(0.6)	(6.9)	(5.4)	(15.7)							(13.0)		(4.4)												
18	4.8	4.4	41.3	20.6	122.2	11.4	3.5	0.3	1.2	6.7	0.7	46.4	48.7	26.7	37.5	4.0	14.6	41.9	0.6	41.6	16.0	40.8	33.1	10.1	57.1	47.0
		(0.6)	(2.0)	(1.9)	(10.6)							(12.6)		(4.5)												
19	4.3	3.6	44.2	21.5	105.4	11.7	3.8	0.1	2.0	7.0	1.2	45.7	47.1	26.9	40.4	3.6	11.2	41.9	0.5	48.1	16.0	41.5	36.1	6.4	58.2	45.2
		(0.6)	(5.3)	(3.0)	(6.6)							(12.1)		(4.4)												
20	5.0	4.6	22.2	20.1	58.1	17.1	6.4	0.6	2.5	9.8	1.6	49.0	50.3	26.7	36.1	3.5	17.2	40.8	0.4	41.0	15.4	34.5	37.4	12.7	56.9	52.3
		(0.1)	(5.3)	(0.7)	(4.8)							(13.0)		(4.5)												
21	5.3	3.4	63.4	27.4	95.1	16.6	4.0	0.6	2.3	11.1	1.5	48.6	51.2	26.5	32.2	4.8	20.2	40.7	1.1	54.7	8.5	25.4	46.0	20.1	71.7	65.0
		(0.2)	(18.6)	(1.0)	(4.7)							(12.2)		(4.2)												
22	3.9	3.4	50.7	27.4	94.9	15.1	4.7	0.2	1.6	9.2	1.8	48.1	50.5	26.5	36.2	5.3	16.3	38.7	2.0	47.5	6.6	23.7	42.9	26.8	81.4	74.4
		(0.2)	(4.6)	(1.1)	(5.2)							(12.3)		(4.0)												
	100	3.6	54.0	22.8	101.7	14.8	4.4	0.5	2.3	9.0	1.3	49.1	50.4	26.3	36.5	4.9	17.0	38.6	1.3	47.3	8.6	26.3	42.0	23.0	64.7	62.5
	39,371	(0.9)	(25.5)	(5.6)	(24.1)							(13.3)		(4.3)												

Table 1-b: Number of observations, average monthly air pollution levels, the prevalence of chronic diseases, and individual and household characteristics by city district in the analyses that include 60 years or older individuals (standard deviations in parentheses)

City District	Num. of Obs. (%)	CO (ppm)	NO2 (ppb)	O3 (ppb)	PM10 (µg/m3)	If Any Chronic (%)	If Diabetes (%)	If Cancer (%)	If Stroke (%)	If Hyper-tenssion (%)	If Asthma (%)	Age (year)	Female (%)	BMI (m/kg2)	If Employed (%)	If Un-employed (%)	If Retired (%)	If Home-maker (%)	If Student (%)	If health Insurance (%)	If Illiterate (%)	If Some School (%)	If Some High School (%)	If Some College (%)	If Car (%)	If Computer (%)
1	4.1	3.1	49.6	29.5	106.9	24.8	8.8	0.6	4.8	14.0	1.1	68.3	43.3	25.6	16.2	1.4	51.0	27.6	1.1	24.5	7.7	20.5	33.9	37.9	69.2	66.7
		(0.0)	(5.3)	(3.2)	(5.3)							(6.7)		(3.9)												
2	7.2	3.5	80.1	24.9	98.0	36.6	6.9	1.9	7.3	23.1	3.5	68.0	41.0	26.3	10.8	2.7	57.3	26.0	0.5	73.5	6.1	25.6	34.2	34.0	72.9	63.2
		(1.2)	(36.1)	(1.8)	(36.2)							(6.8)		(4.6)												
3	4.6	3.1	44.1	29.7	107.2	30.7	4.8	1.5	7.8	20.1	0.8	68.7	42.0	25.8	18.1	2.3	49.7	27.1	0.0	24.1	3.8	18.6	38.7	38.9	74.9	69.8
		(0.1)	(4.0)	(5.4)	(5.0)							(7.0)		(4.0)												
4	4.9	2.7	73.3	17.5	92.1	37.3	14.1	0.9	7.7	21.8	2.3	67.5	42.7	25.9	11.7	2.3	54.0	29.3	0.0	54.9	15.5	38.3	29.6	16.7	66.0	53.8
		(0.4)	(24.5)	(6.9)	(12.5)							(6.5)		(4.0)												
5	4.8	3.8	60.4	24.9	98.1	36.7	8.4	1.0	9.8	24.9	1.9	67.5	42.9	26.7	10.1	3.6	53.7	30.7	0.2	59.2	12.5	27.6	34.8	25.2	65.5	61.2
		(1.0)	(14.6)	(1.8)	(37.5)							(6.8)		(4.2)												
6	9.2	3.3	46.5	27.4	92.8	34.0	11.3	1.5	5.0	21.3	2.4	70.0	45.5	25.4	12.8	1.9	51.7	29.3	0.8	58.6	7.7	23.3	35.2	33.8	57.5	59.0
		(0.6)	(27.7)	(4.5)	(13.7)							(7.8)		(3.7)												
7	4.0	3.3	37.9	26.5	94.3	36.5	12.5	0.9	9.3	20.6	3.8	69.7	48.1	26.1	13.9	1.7	46.7	35.9	0.0	63.2	14.8	35.7	30.4	19.1	56.2	52.5
		(0.5)	(9.6)	(3.6)	(7.6)							(7.3)		(4.3)												
8	5.9	2.6	35.0	22.5	90.6	38.9	12.9	1.4	7.2	27.0	2.0	69.8	43.6	26.0	10.4	2.7	49.7	34.2	0.0	47.6	18.0	47.2	23.1	11.7	53.0	45.4
		(0.1)	(9.7)	(2.1)	(4.2)							(7.3)		(4.4)												
9	4.3	5.2	68.5	20.0	132.7	42.1	11.7	1.1	9.5	28.0	1.9	69.1	44.8	26.1	7.3	2.4	50.5	37.2	0.5	53.8	35.1	45.9	16.6	2.4	35.3	32.1
		(0.2)	(40.3)	(1.4)	(8.8)							(7.2)		(4.0)												
10	4.0	4.6	80.4	14.6	129.1	21.2	5.5	0.6	4.4	13.4	1.7	69.5	45.3	25.4	11.0	2.6	47.4	36.0	0.0	60.2	30.2	49.1	16.6	4.1	36.0	39.8
		(1.0)	(41.0)	(4.7)	(18.5)							(7.2)		(4.0)												
11	4.2	3.5	61.4	14.3	88.5	27.6	7.5	1.4	3.9	20.6	2.2	68.6	46.0	26.2	13.6	3.3	45.7	32.0	0.6	68.5	21.4	44.8	23.1	10.6	39.0	44.6
		(0.5)	(20.1)	(6.5)	(8.4)							(7.0)		(4.2)												
12	4.4	3.7	73.3	26.2	93.9	24.2	4.9	0.8	5.7	16.9	2.9	68.0	44.0	26.3	17.2	6.8	31.3	37.0	0.5	48.4	25.3	46.9	18.5	9.4	38.5	41.9
		(0.2)	(9.9)	(3.2)	(13.4)							(6.4)		(4.4)												
13	4.4	3.0	44.8	24.3	98.9	20.6	7.7	0.5	3.2	12.4	1.1	68.6	44.3	26.2	15.0	4.5	42.2	32.5	1.6	53.3	15.8	49.9	23.5	10.8	51.2	47.5
		(0.6)	(17.0)	(2.0)	(18.2)							(6.7)		(4.5)												
14	5.7	3.6	50.6	26.5	132.0	38.2	11.6	1.2	5.9	26.5	1.6	69.3	43.9	26.6	13.9	3.5	44.3	34.9	0.6	48.8	32.2	48.2	15.5	4.1	43.7	34.7
		(0.4)	(6.7)	(1.4)	(10.8)							(6.9)		(4.6)												
15	3.3	4.1	46.7	22.6	127.9	32.5	5.6	2.1	6.3	22.0	3.1	67.4	42.7	26.7	15.7	5.9	35.3	36.0	0.3	52.1	39.2	50.7	9.1	1.0	38.1	32.9
		(0.6)	(7.8)	(3.8)	(21.9)							(6.2)		(4.9)												
16	3.1	2.8	48.7	16.9	86.9	34.8	7.4	0.7	5.6	24.4	3.7	69.4	48.1	26.1	8.5	5.6	40.0	39.3	0.0	55.6	51.9	40.4	6.7	1.1	31.5	27.8
		(0.7)	(10.6)	(2.2)	(13.3)							(6.3)		(4.3)												
17	3.3	3.7	45.0	18.4	107.8	15.6	5.2	0.3	2.8	9.3	1.0	68.4	46.7	26.4	9.0	4.8	48.1	34.3	0.7	38.1	53.6	38.1	7.3	1.0	36.7	31.1
		(0.6)	(5.4)	(5.3)	(15.8)							(6.7)		(4.5)												
18	3.6	4.4	41.3	20.5	123.3	26.3	7.3	1.3	2.5	17.1	0.3	67.5	43.5	26.9	7.6	3.2	48.9	35.2	0.6	46.0	46.7	45.1	6.7	1.6	39.4	30.8
		(0.6)	(2.3)	(1.8)	(9.8)							(6.8)		(5.1)												
19	2.7	3.6	44.4	21.6	105.6	27.9	7.0	0.4	6.6	19.2	3.1	67.9	38.0	27.1	13.1	3.1	44.1	31.4	0.0	54.6	49.8	42.8	6.1	1.3	45.0	34.1
		(0.6)	(5.8)	(3.0)	(5.9)							(6.6)		(4.8)												
20	4.8	4.6	22.1	20.1	58.1	34.1	12.2	1.2	5.8	21.3	2.9	68.5	45.3	26.2	13.2	3.6	46.3	32.1	0.0	41.5	42.9	41.2	12.5	3.4	36.7	33.3
		(0.1)	(5.5)	(0.7)	(5.2)							(6.8)		(4.7)												
21	4.3	3.3	60.7	27.5	94.7	34.8	9.4	1.1	6.7	24.1	2.9	67.5	41.4	26.5	7.0	2.7	54.3	32.9	0.8	57.5	28.1	41.4	24.3	6.1	51.6	47.3
		(0.0)	(18.0)	(0.4)	(1.2)							(6.7)		(4.1)												
22	3.1	3.3	50.7	27.4	94.5	34.7	10.4	0.4	6.3	21.6	3.4	67.7	38.4	26.7	9.3	4.5	52.2	29.5	0.4	53.0	22.4	36.6	24.3	16.8	66.0	56.0
		(0.1)	(3.0)	(1.4)	(3.4)							(6.5)		(4.3)												
	100	3.6	53.5	23.3	101.5	32.1	9.1	1.1	6.2	20.9	2.3	68.6	43.8	26.2	12.2	3.3	48.2	32.3	0.4	52.5	23.6	37.8	23.2	15.4	51.8	47.4
	8,635	(0.9)	(25.4)	(5.7)	(24.1)							(7.0)		(4.3)												

Table 2: Number of individuals with and without any of the chronic disorders in the analysis sample

Age Range	1: with 0: without	Any Chronic	Diabetes	Cancer	Stroke	Hypertension	Asthma
All Ages	1	9.0%	2.6%	0.3%	1.4%	5.3%	1.0%
	0	91.0%	97.4%	99.7%	98.6%	94.7%	99.0%
	N	67,049	67,049	67,049	67,049	67,049	67,049
30+ Year Olds	1	14.8%	4.4%	0.5%	2.3%	9.0%	1.3%
	0	85.2%	95.6%	99.5%	97.7%	91.0%	98.7%
	N	39,371	39,371	39,371	39,371	39,371	39,371
40+ Year Olds	1	19.6%	5.8%	0.6%	3.1%	12.1%	1.6%
	0	80.4%	94.2%	99.4%	96.9%	87.9%	98.4%
	N	28,203	28,203	28,203	28,203	28,203	28,203
50+ Year Olds	1	25.9%	7.7%	0.8%	4.5%	16.4%	1.9%
	0	74.1%	92.3%	99.2%	95.5%	83.6%	98.1%
	N	17,724	17,724	17,724	17,724	17,724	17,724
60+ Year Olds	1	32.1%	9.1%	1.1%	6.2%	20.9%	2.3%
	0	67.9%	90.9%	98.9%	93.8%	79.1%	97.7%
	N	8,635	8,635	8,635	8,635	8,635	8,635

Table 3: (single-pollutant regressions): Number of people with a chronic disease per 100,000 per 1 ppm, 1 ppb, 1 ppb, and 1 μg/m[3] change in the average monthly CO, NO2, O3, and PM10 over two years

Age Range	Air Pollutant	Any Chronic	Diabetes	Cancer	Stroke	Hypertension	Asthma
All Ages	CO	751.0***	329.0***	10.6	232.0***	321.0*	129.0**
		(239.0)	(76.1)	(44.2)	(85.5)	(164.0)	(52.6)
	NO2	18.2***	9.9	0.6	5.7	9.2	-1.5
		(5.8)	(7.1)	(1.4)	(4.8)	(6.6)	(2.1)
	O3	46.1	15.5	-5.2	-7.1	23.1	20.8*
		(73.5)	(15.2)	(7.6)	(21.8)	(58.8)	(12.0)
	PM10	23.6**	5.4	1.5	6.4	8.8	2.7
		(11.1)	(6.5)	(1.4)	(4.7)	(6.5)	(6.0)
	N	67,049	67,049	67,049	67,049	67,049	67,049
30+ Year Olds	CO	1240.0***	528.0***	22.3	407.0**	574.0*	185.0**
		(407.0)	(153.0)	(75.7)	(144.0)	(293.0)	(83.0)
	NO2	29.0***	17.5	1.3	9.7	12.9	-3.1
		(8.1)	(13.0)	(1.9)	(7.9)	(10.5)	(3.0)
	O3	62.7	17.8	-11.7	-10.5	47.7	21.4
		(115.0)	(26.1)	(14.4)	(38.5)	(95.3)	(18.6)
	PM10	33.1*	9.1	2.3	10.9	12.8	-0.5
		(17.4)	(11.3)	(2.4)	(7.9)	(11.7)	(9.1)
	N	39,371	39,371	39,371	39,371	39,371	39,371
40+ Year Olds	CO	1870.0**	854.0***	29.6	606.0**	829.0*	210.0
		(676.0)	(208.0)	(118.0)	(227.0)	(418.0)	(136.0)
	NO2	33.0**	24.7	1.6	11.0	17.6	-8.7
		(11.7)	(18.2)	(2.4)	(10.8)	(14.1)	(5.2)
	O3	61.7	31.9	-24.5	-25.1	27.4	46.8*
		(165.0)	(29.8)	(23.3)	(58.4)	(132.0)	(22.9)
	PM10	23.6**	18.0	5.4	15.4	21.4	-0.8
		(28.8)	(16.1)	(3.8)	(11.8)	(18.4)	(16.0)
	N	28,203	28,203	28,203	28,203	28,203	28,203
50+ Year Olds	CO	2360.0*	1380.0***	48.2	833.0**	868.0	251.0
		(1,190.0)	(349.0)	(168.0)	(358.0)	(879.0)	(169.0)
	NO2	25.2*	32.2	3.6	10.5	13.5	-12.8*
		(14.1)	(28.1)	(2.5)	(16.3)	(17.8)	(7.4)
	O3	157.0	66.4	-16.3	-43.8	73.3	62.7*
		(264.0)	(58.8)	(29.1)	(109.0)	(191.0)	(35.0)
	PM10	71.8	23.3	6.5	23.8	22.1	-1.3
		(45.4)	(23.2)	(5.5)	(18.2)	(35.9)	(19.2)
	N	17,724	17,724	17,724	17,724	17,724	17,724
60+ Year Olds	CO	2740.0	1350.0**	-43.4	901.0	1630.0	271.0
		(1,830.0)	(637.0)	(248.0)	(798.0)	(1,810.0)	(305.0)
	NO2	15.1	49.8	1.7	23.7	-24.6	-21.2*
		(23.4)	(47.3)	(2.2)	(34.2)	(20.5)	(10.5)
	O3	111.0	42.4	-69.6	-135.0	96.5	107.0
		(373.0)	(115.0)	(59.8)	(140.0)	(268.0)	(75.9)
	PM10	66.5	32.4	5.1	11.8	51.9	-20.5
		(60.6)	(33.1)	(9.7)	(33.2)	(54.2)	(33.5)
	N	8,635	8,635	8,635	8,635	8,635	8,635

Notes: Numbers in parentheses are standard errors. ***, **, and * indicate 1%, 5%, and 10% levels of statistical significance.

Table 4: The Pearson correlation coefficient of the trends of average monthly concentration levels of every two air pollutants by air quality monitor

Air Quality Monitor	CO vs. NO2	CO vs. O3	CO vs. PM10	NO2 vs. O3	NO2 vs. PM10	O3 vs. PM10
1	0.69	0.00	-	0.30	-	-
2	0.48	0.37	0.12	0.35	0.21	0.46
3	0.78	0.50	-	0.12	-	-
4	0.80	0.22	0.34	0.09	0.29	0.14
5	-	0.25	0.41	-	-	0.15
6	0.74	0.54	0.53	0.55	0.47	0.06
7	0.07	0.43	0.02	0.46	0.17	0.03
8	-	0.25	0.27	-	-	0.12
9	0.69	0.32	0.39	0.46	0.02	0.07
10	-	0.27	0.39	-	-	0.38
11	0.42	0.04	0.17	0.25	0.41	0.35
12	0.44	0.24	0.25	0.44	0.37	0.13
13	-	0.31	0.20	-	-	0.06
Average	0.57	0.29	0.28	0.34	0.28	0.18

Table 5 (multi-pollutant regressions): Number of people with a chronic disease per 100,000 per 1 ppm, 1 ppb, and 1 μg/m^3 change in the average monthly CO, NO2, O3, and PM10 over two years

Age Range	Air Pollutant	Any Chronic	Diabetes	Cancer	Stroke	Hypertension	Asthma
All Ages	CO	687.0***	329.0***	17.3	259.0***	291.0*	96.4*
		(194.0)	(85.0)	(47.7)	(80.0)	(146.0)	(54.6)
	NO2	-	-	-	-	-	-
		-	-	-	-	-	-
	O3	-9.5	-6.9	-7.5	-26.9	0.5	13.9
		(77.2)	(10.4)	(8.6)	(20.0)	(61.5)	(14.6)
	PM10	18.4*	3.0	1.7	5.4	6.4	1.4
		(10.5)	(6.0)	(1.4)	(3.6)	(6.6)	(6.0)
	N	67,049	67,049	67,049	67,049	67,049	67,049
30+ Year Olds	CO	1180.0***	538.0***	39.7	447.0***	518.0**	174.0*
		(305.0)	(173.0)	(81.3)	(137.0)	(242.0)	(92.4)
	NO2	-	-	-	-	-	-
		-	-	-	-	-	-
	O3	-27.4	-18.9	-16.1	-44.5	10.2	12.7
		(115.0)	(17.1)	(15.5)	(35.8)	(97.5)	(22.1)
	PM10	24.0	5.2	2.6	8.9	7.9	-2.5
		(16.9)	(10.8)	(2.4)	(6.1)	(12.1)	(9.0)
	N	39,371	39,371	39,371	39,371	39,371	39,371
40+ Year Olds	CO	1820.0***	850.0***	58.9	685.0***	815.0**	155.0
		(499.0)	(213.0)	(128.0)	(212.0)	(357.0)	(146.0)
	NO2	-	-	-	-	-	-
		-	-	-	-	-	-
	O3	-82.4	-29.1	-33.3	-77.1	-34.8	40.9
		(163.0)	(18.2)	(24.6)	(53.4)	(136.0)	(25.2)
	PM10	40.7	11.3	6.4	12.5	15.3	-4.2
		(27.0)	(15.7)	(4.0)	(9.3)	(17.7)	(16.5)
	N	28,203	28,203	28,203	28,203	28,203	28,203
50+ Year Olds	CO	2140.0**	1380.0***	63.0	960.0***	772.0	170.0
		(816.0)	(369.0)	(185.0)	(292.0)	(671.0)	(181.0)
	NO2	-	-	-	-	-	-
		-	-	-	-	-	-
	O3	-19.7	-28.9	-26.1	-120.0	13.3	56.7*
		(234.0)	(45.4)	(32.2)	(104.0)	(175.0)	(31.7)
	PM10	53.8	12.4	7.1	20.9	14.7	-5.4
		(40.5)	(22.6)	(6.3)	(15.4)	(31.4)	(19.7)
	N	17,724	17,724	17,724	17,724	17,724	17,724
60+ Year Olds	CO	2710.0*	1370.0*	71.6	1290.0	1500.0	186.0
		(1,420.0)	(695.0)	(294.0)	(864.0)	(1,790.0)	(327.0)
	NO2	-	-	-	-	-	-
		-	-	-	-	-	-
	O3	-110.0	-68.6	-80.9	-230.0	-37.0	117.0*
		(337.0)	(106.0)	(61.7)	(164.0)	(267.0)	(66.4)
	PM10	45.6	22.4	7.8	9.3	39.3	-27.2
		(50.1)	(35.5)	(10.5)	(28.2)	(44.6)	(35.4)
	N	8,635	8,635	8,635	8,635	8,635	8,635

Notes: Numbers in parentheses are standard errors. ***, **, and * indicate 1%, 5%, and 10% levels of statistical significance.

Table 6: Potential YYLs gains from a 1 ppm decrease in average monthly CO level over two years

	Diabetes	Stroke	Asthma	Hypertension
A: Change in Reporting Chronic Diseases (in 100,000), Results from the Multi-Pollutant Analyses				
30 Years or Older	538	447	174	518
	(173)	(81)	(137)	(242)
40 Years or Older	850	685	155	815
	(213)	(128)	(212)	(357)
50 Years or Older	1,380	960	170	772
	(369)	(185)	(292)	(671)
60 Years or Older	1,370	1,290	186	1,500
	(695)	(294)	(864)	(1,790)
B: Calculated YLLs Using Results of the GBD Project (in 100,000)				
30 Years or Older	862	1,692	194	4,823
	(12)	(17)	(2)	(91)
40 Years or Older	1,172	2,268	253	6,517
	(17)	(24)	(3)	(125)
50 Years or Older	1,709	3,289	354	9,411
	(26)	(37)	(5)	(191)
60 Years or Older	2,508	5,259	541	14,306
	(47)	(69)	(9)	(350)
C: Change in YLLs (in 100,000)				
30 Years or Older	4.6	7.6	0.3	25.0
	(1.5)	(1.4)	(0.3)	(11.7)
40 Years or Older	10.0	15.5	0.4	53.1
	(2.5)	(2.9)	(0.5)	(23.3)
50 Years or Older	23.6	31.6	0.6	72.7
	(6.3)	(6.1)	(1.0)	(63.2)
60 Years or Older	34.4	67.8	1.0	214.6
	(17.4)	(15.5)	(4.7)	(256.2)
D: Total Change in YLLs				
30 Years or Older	208	339	15	1,119
	(67)	(62)	(12)	(523)
40 Years or Older	299	467	12	1,596
	(75)	(87)	(16)	(700)
50 Years or Older	430	575	11	1,324
	(115)	(111)	(19)	(1,151)
60 Years or Older	319	630	9	1,992
	(162)	(144)	(43)	(2,378)

Notes: Numbers in parentheses are standard deviations.

Table 7: Distribution of individuals in terms of activity by age and gender (Tehranis surveyed during 2002–2011)

	Number of Obs	Employed	Unemployed, Job Seeker	Unemployed with Income	Student	Home-maker	Other
30 Years or Older							
pooled	19,269	41.7%	2.0%	18.5%	0.4%	36.2%	1.3%
males	9,681	72.8%	3.2%	21.9%	0.1%	0.2%	1.8%
females	9,588	10.2%	0.7%	15.1%	0.8%	72.6%	0.7%
40 Years or Older							
pooled	13,258	36.0%	1.4%	26.2%	0.2%	34.7%	1.5%
males	6,716	63.9%	2.4%	31.2%	0.1%	0.2%	2.2%
females	6,542	7.4%	0.2%	21.1%	0.3%	70.1%	0.9%
50 Years or Older							
pooled	7,908	26.2%	1.0%	39.9%	0.0%	30.9%	2.1%
males	4,116	47.3%	1.7%	47.8%	0.0%	0.3%	2.9%
females	3,792	3.2%	0.1%	31.2%	0.0%	64.1%	1.3%
60 Years or Older							
pooled	4,058	15.3%	0.8%	54.8%	0.0%	25.6%	3.5%
males	2,196	27.6%	1.4%	66.4%	0.0%	0.4%	4.3%
females	1,862	0.8%	0.2%	41.1%	0.0%	55.4%	2.6%

Table 8: Average inflation-adjusted annual labor and non-labor income of a Tehrani with reported income by age and gender during 2002–2011 in 2011 thousand Iranian tomans and US dollar

	Thousand Iranian Toman			US dollar		
	Labor Market Income	Non-Labor Market Income	Total Income	Labor Market Income	Non-Labor Market Income	Total Income
	30 Years or Older					
Pooled	9,387	5,984	8,834	7,823	4,987	7,362
	(143)	(79)	(109)	(119)	(66)	(90)
N	7,976	4,798	11,870	7,976	4,798	11,870
Males	9,844	6,443	9,708	8,204	5,369	8,090
	(158)	(108)	(133)	(132)	(90)	(111)
N	7,022	3,136	9,304	7,022	3,136	9,304
Females	6,028	5,118	5,669	5,023	4,265	4,724
	(251)	(97)	(125)	(209)	(81)	(104)
N	954	1,662	2,566	954	1,662	2,566
	40 Years or Older					
Pooled	10,285	6,135	9,140	8,571	5,113	7,617
	(228)	(81)	(145)	(190)	(67)	(120)
N	4,745	4,498	8,446	4,745	4,498	8,446
Males	10,708	6,631	10,186	8,923	5,526	8,489
	(246)	(110)	(181)	(205)	(92)	(151)
N	4,278	2,946	6,485	4,278	2,946	6,485
Females	6,418	5,194	5,682	5,348	4,328	4,735
	(483)	(100)	(141)	(403)	(83)	(118)
N	467	1,552	1,961	467	1,552	1,961
	50 Years or Older					
Pooled	10,552	6,303	8,615	8,794	5,253	7,179
	(426)	(86)	(191)	(355)	(72)	(159)
N	2,056	3,809	5,364	2,056	3,809	5,364
Males	10,793	6,885	9,738	8,994	5,737	8,115
	(450)	(117)	(253)	(375)	(98)	(211)
N	1,939	2,517	3,976	1,939	2,517	3,976
Females	6,578	5,171	5,402	5,481	4,310	4,502
	(516)	(102)	(108)	(430)	(85)	(90)
N	117	1,292	1,388	117	1,292	1,388
	60 Years or Older					
Pooled	10,009	6,128	7,420	8,341	5,107	6,183
	(851)	(111)	(242)	(709)	(92)	(202)
N	615	2,518	2,933	615	2,518	2,933
Males	10,158	6,738	8,423	8,465	5,615	7,019
	(870)	(152)	(332)	(725)	(126)	(277)
N	601	1,696	2,102	601	1,696	2,102
Females	3,599	4,871	4,888	2,999	4,059	4,074
	(870)	(122)	(122)	(725)	(102)	(102)
N	14	822	831	14	822	831

Notes: Numbers in parentheses are standard deviations.

Table 9: Expected inflation-adjusted annual labor and non-labor income of a Tehrani by age and gender during 2002–2011 in 2011 thousand Iranian tomans and US dollar

	Thousand Iranian Toman			US dollar		
	Labor Market Income	Non-Labor Market Income	Total Income	Labor Market Income	Non-Labor Market Income	Total Income
	30 Years or Older					
Pooled	3,933	1,483	5,416	3,277	1,236	4,513
	(68)	(27)	(73)	(57)	(23)	(61)
N	19,361	19,361	19,361	19,361	19,361	19,361
Males	7,210	2,078	9,288	6,008	1,732	7,740
	(123)	(46)	(129)	(102)	(39)	(107)
N	9,723	9,723	9,723	9,723	9,723	9,723
Females	627	883	1,510	522	736	1,258
	(34)	(26)	(42)	(28)	(22)	(35)
N	9,638	9,638	9,638	9,638	9,638	9,638
	40 Years or Older					
Pooled	3,714	2,068	5,782	3,095	1,723	4,818
	(91)	(37)	(99)	(76)	(31)	(83)
N	13,350	13,350	13,350	13,350	13,350	13,350
Males	6,882	2,892	9,774	5,735	2,410	8,145
	(168)	(63)	(176)	(140)	(52)	(147)
N	6,758	6,758	6,758	6,758	6,758	6,758
Females	468	1,223	1,691	390	1,019	1,409
	(40)	(36)	(53)	(33)	(30)	(44)
N	6,592	6,592	6,592	6,592	6,592	6,592
	50 Years or Older					
Pooled	2,775	3,002	5,777	2,312	2,502	4,814
	(121)	(54)	(136)	(101)	(45)	(113)
N	8,000	8,000	8,000	8,000	8,000	8,000
Males	5,143	4,168	9,312	4,286	3,474	7,760
	(226)	(88)	(244)	(188)	(74)	(203)
N	4,158	4,158	4,158	4,158	4,158	4,158
Females	213	1,740	1,953	177	1,450	1,627
	(25)	(52)	(57)	(20)	(44)	(48)
N	3,842	3,842	3,842	3,842	3,842	3,842
	60 Years or Older					
Pooled	1,525	3,721	5,245	1,271	3,101	4,371
	(137)	(82)	(179)	(115)	(68)	(149)
N	4,150	4,150	4,150	4,150	4,150	4,150
Males	2,803	5,109	7,912	2,335	4,258	6,593
	(252)	(130)	(315)	(210)	(108)	(263)
N	2,238	2,238	2,238	2,238	2,238	2,238
Females	30	2,097	2,127	25	1,748	1,773
	(10)	(76)	(77)	(8)	(64)	(64)
N	1,912	1,912	1,912	1,912	1,912	1,912

Notes: Numbers in parentheses are standard deviations.

Table 10–1 (diabetes): Life-time income gained due to the decrease in the burden of diabetes associated with a 1 ppm decrease in average monthly CO level over two years (per 100,000)

	Million Iranian Toman			Thousand US dollar		
	Labor Market Income	Non-Labor Market Income	Total Income	Labor Market Income	Non-Labor Market Income	Total Income
	30 Years or Older					
Pooled	18.234	6.876	25.110	15.195	5.730	20.925
	(5.879)	(2.217)	(8.091)	(4.899)	(1.848)	(6.742)
Males	33.429	9.635	43.064	27.857	8.029	35.887
	(10.777)	(3.110)	(13.876)	(8.981)	(2.591)	(11.563)
Females	2.907	4.094	7.001	2.422	3.412	5.834
	(0.950)	(1.324)	(2.263)	(0.792)	(1.103)	(1.886)
	40 Years or Older					
Pooled	36.999	20.598	57.597	30.833	17.165	47.998
	(9.335)	(5.184)	(14.494)	(7.779)	(4.320)	(12.078)
Males	68.558	28.808	97.366	57.132	24.007	81.139
	(17.295)	(7.260)	(24.507)	(14.413)	(6.050)	(20.423)
Females	4.661	12.185	16.846	3.884	10.154	14.038
	(1.240)	(3.081)	(4.263)	(1.033)	(2.567)	(3.553)
	50 Years or Older					
Pooled	65.439	70.794	136.233	54.533	58.995	113.528
	(17.776)	(19.009)	(36.642)	(14.813)	(15.841)	(30.535)
Males	121.300	98.305	219.605	101.083	81.921	183.004
	(32.955)	(26.420)	(59.123)	(27.462)	(22.017)	(49.269)
Females	5.015	41.035	46.050	4.179	34.196	38.375
	(1.471)	(11.065)	(12.414)	(1.226)	(9.221)	(10.345)
	60 Years or Older					
Pooled	52.387	127.832	180.218	43.655	106.526	150.182
	(27.120)	(64.980)	(91.762)	(22.600)	(54.150)	(76.468)
Males	96.287	175.530	271.818	80.239	146.275	226.515
	(49.841)	(89.263)	(138.542)	(41.534)	(74.385)	(115.452)
Females	1.044	72.047	73.090	0.870	60.039	60.909
	(0.646)	(36.698)	(37.229)	(0.539)	(30.582)	(31.024)

Notes: Numbers in parentheses are standard deviations.

Table 10–2 (strokes & myocardial infarction): Life-time income gained due to the decrease in the burden of strokes associated with a 1 ppm decrease in average monthly CO level over two years (per 100,000)

	Million Iranian Toman			Thousand US dollar		
	Labor Market Income	Non-Labor Market Income	Total Income	Labor Market Income	Non-Labor Market Income	Total Income
	30 Years or Older					
Pooled	29.744	11.218	40.962	24.787	9.348	34.135
	(5.444)	(2.054)	(7.484)	(4.537)	(1.712)	(6.236)
Males	54.532	15.717	70.250	45.444	13.098	58.541
	(9.979)	(2.886)	(12.836)	(8.316)	(2.405)	(10.697)
Females	4.742	6.679	11.421	3.952	5.566	9.517
	(0.903)	(1.233)	(2.105)	(0.752)	(1.027)	(1.755)
	40 Years or Older					
Pooled	57.705	32.125	89.830	48.087	26.771	74.858
	(10.897)	(6.041)	(16.886)	(9.081)	(5.034)	(14.072)
Males	106.925	44.929	151.854	89.104	37.441	126.545
	(20.188)	(8.468)	(28.558)	(16.823)	(7.056)	(23.799)
Females	7.269	19.004	26.273	6.057	15.837	21.894
	(1.500)	(3.602)	(4.988)	(1.250)	(3.002)	(4.157)
	50 Years or Older					
Pooled	87.614	94.783	182.396	73.011	78.986	151.997
	(17.356)	(18.380)	(35.482)	(14.463)	(15.317)	(29.569)
Males	162.402	131.616	294.018	135.335	109.680	245.015
	(32.180)	(25.567)	(57.300)	(26.817)	(21.306)	(47.750)
Females	6.714	54.940	61.654	5.595	45.783	51.378
	(1.518)	(10.739)	(12.044)	(1.265)	(8.949)	(10.037)
	60 Years or Older					
Pooled	103.433	252.393	355.827	86.194	210.328	296.522
	(25.477)	(57.904)	(82.188)	(21.231)	(48.253)	(68.490)
Males	190.112	346.571	536.683	158.427	288.809	447.236
	(46.804)	(79.641)	(124.474)	(39.004)	(66.367)	(103.728)
Females	2.061	142.251	144.311	1.717	118.542	120.259
	(0.817)	(32.908)	(33.380)	(0.681)	(27.424)	(27.817)

Notes: Numbers in parentheses are standard deviations.

Table 10–3 (asthma): Life-time income gained due to the decrease in the burden of asthma associated with a 1 ppm decrease in average monthly CO level over two year (per 100,000)

	Million Iranian Toman			Thousand US dollar		
	Labor Market Income	Non-Labor Market Income	Total Income	Labor Market Income	Non-Labor Market Income	Total Income
	30 Years or Older					
Pooled	1.328	0.501	1.829	1.107	0.417	1.524
	(1.046)	(0.395)	(1.440)	(0.872)	(0.329)	(1.200)
Males	2.435	0.702	3.136	2.029	0.585	2.614
	(1.918)	(0.553)	(2.470)	(1.598)	(0.461)	(2.059)
Females	0.212	0.298	0.510	0.176	0.248	0.425
	(0.167)	(0.235)	(0.402)	(0.139)	(0.196)	(0.335)
	40 Years or Older					
Pooled	1.456	0.811	2.267	1.214	0.676	1.889
	(1.993)	(1.109)	(3.102)	(1.661)	(0.924)	(2.585)
Males	2.699	1.134	3.833	2.249	0.945	3.194
	(3.693)	(1.552)	(5.244)	(3.078)	(1.293)	(4.370)
Females	0.183	0.480	0.663	0.153	0.400	0.553
	(0.252)	(0.657)	(0.908)	(0.210)	(0.547)	(0.756)
	50 Years or Older					
Pooled	1.668	1.804	3.472	1.390	1.504	2.893
	(2.869)	(3.100)	(5.967)	(2.391)	(2.583)	(4.972)
Males	3.091	2.505	5.597	2.576	2.088	4.664
	(5.317)	(4.305)	(9.619)	(4.431)	(3.588)	(8.016)
Females	0.128	1.046	1.174	0.106	0.871	0.978
	(0.221)	(1.798)	(2.017)	(0.185)	(1.498)	(1.681)
	60 Years or Older					
Pooled	1.534	3.744	5.278	1.278	3.120	4.398
	(7.158)	(17.396)	(24.534)	(5.965)	(14.497)	(20.445)
Males	2.820	5.140	7.960	2.350	4.284	6.634
	(13.155)	(23.889)	(37.012)	(10.963)	(19.908)	(30.843)
Females	0.031	2.110	2.140	0.025	1.758	1.784
	(0.149)	(9.809)	(9.951)	(0.124)	(8.174)	(8.292)

Notes: Numbers in parentheses are standard deviations.

Table 10–4 (hypertension): Life-time income gained due to the decrease in the burden of hypertension associated with a 1 ppm decrease in average monthly CO level over two year (per 100,000)

	Million Iranian Toman			Thousand US dollar		
	Labor Market Income	Non-Labor Market Income	Total Income	Labor Market Income	Non-Labor Market Income	Total Income
	30 Years or Older					
Pooled	98.257	37.056	135.313	81.881	30.880	112.761
	(45.987)	(17.345)	(63.310)	(38.323)	(14.454)	(52.758)
Males	180.141	51.921	232.061	150.117	43.267	193.384
	(84.309)	(24.314)	(108.579)	(70.257)	(20.262)	(90.483)
Females	15.664	22.062	37.727	13.054	18.385	31.439
	(7.385)	(10.342)	(17.681)	(6.155)	(8.618)	(14.734)
	40 Years or Older					
Pooled	197.289	109.833	307.122	164.408	91.528	255.935
	(86.681)	(48.214)	(134.807)	(72.234)	(40.178)	(112.340)
Males	365.568	153.610	519.178	304.640	128.009	432.648
	(160.610)	(67.462)	(227.908)	(133.842)	(56.218)	(189.923)
Females	24.852	64.974	89.825	20.710	54.145	74.855
	(11.142)	(28.570)	(39.511)	(9.285)	(23.808)	(32.926)
	50 Years or Older					
Pooled	201.591	218.086	419.677	167.992	181.739	349.731
	(175.687)	(189.717)	(365.181)	(146.406)	(158.097)	(304.317)
Males	373.673	302.836	676.509	311.394	252.363	563.758
	(325.666)	(263.480)	(588.752)	(271.389)	(219.566)	(490.627)
Females	15.448	126.412	141.859	12.873	105.343	118.216
	(13.640)	(110.041)	(123.482)	(11.366)	(91.701)	(102.902)
	60 Years or Older					
Pooled	327.197	798.411	1,125.608	272.664	665.343	938.007
	(393.344)	(953.650)	(1,345.244)	(327.787)	(794.708)	(1,121.037)
Males	601.392	1,096.329	1,697.722	501.160	913.608	1,414.768
	(722.939)	(1,309.676)	(2,029.714)	(602.449)	(1,091.396)	(1,691.429)
Females	6.519	449.990	456.509	5.432	374.992	380.424
	(8.418)	(537.868)	(545.653)	(7.015)	(448.223)	(454.711)

Notes: Numbers in parentheses are standard deviations.